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Comparison of Raman Scattering Measurements and Modeling in NIF Ignition Experiments

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Lawrence Livermore National Laboratory

APS-DPP Salt Lake City

November 17, 2011

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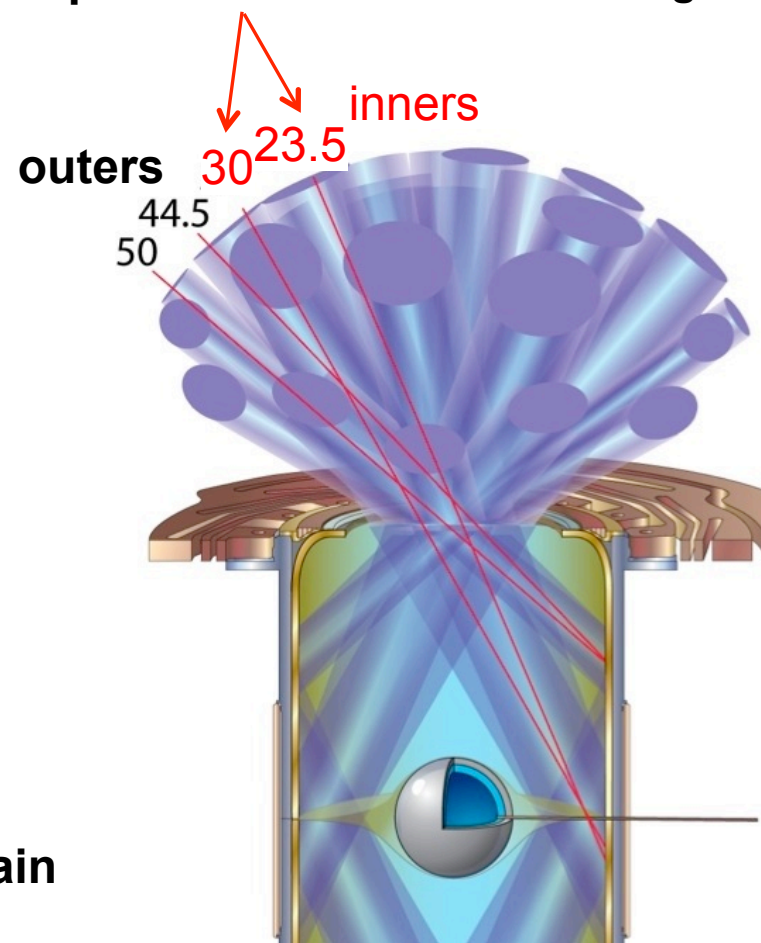
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Raman measurements and linear gain analyses agree in mid peak power, differ early and late

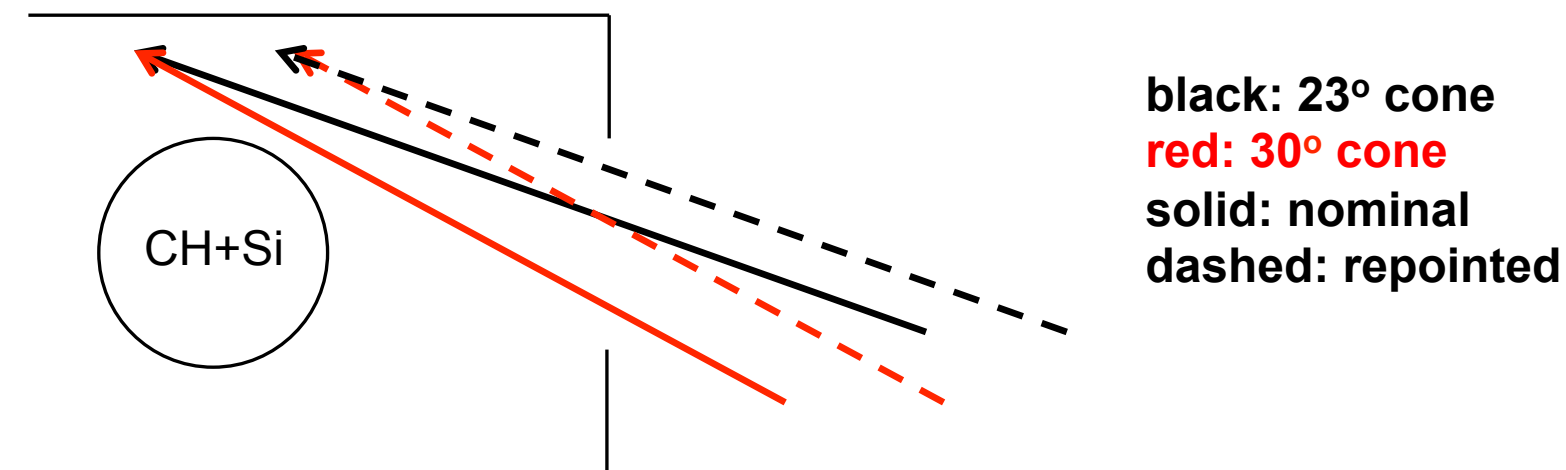
- “High Flux Model” (HFM) for rad-hydro:
 - DCA opacities, $f=0.15$ electron heat flux limiter
 - Cross-beam energy transfer: linear model w/ clamp
 - Measured backscatter removed
- Linear gain spectrum and measurements:
 - Early peak power: gain **redshifted** from measurement
 - Mid peak power: they agree well
 - Late peak power: gain **redshifted** again
- Overlapped laser (multi-quad) intensity:
 - Early peak power: gain spectrum **blueshifted**
- Gain and reflectivity time histories:
 - Early peak power: large reflectivity but small gain
 - Gain continuously increases in time
 - Reflectivity decreases late in peak power

23° and 30° cone diagnostics:
 FABS: full aperture
 backscatter station
 NBI: near-backscatter imager



Raman scattering on N111014: symcap with 30° cone pulled away from capsule

- Inner-cone repointing series
 - 1.2 MJ laser energy
 - Si-doped symmetry capsules
 - scale 5.75mm gold hohlraum
 - 3 laser colors to control spherical and azimuthal symmetry
 - $\lambda_{30} = \lambda_{\text{outer}} + 7.5 \text{ \AA}$ $\lambda_{23} = \lambda_{30} + 1 \text{ \AA}$

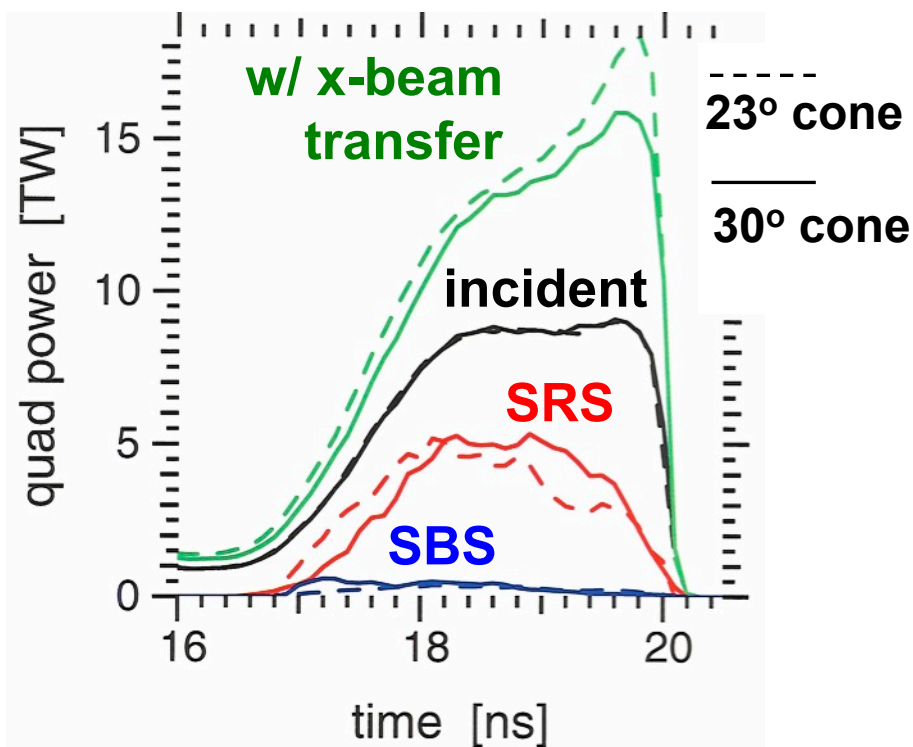


this talk focuses on this shot,
 SRS from 30° cone

N111013: nominal
 N111014: 30° repointed
 N111016: both repointed

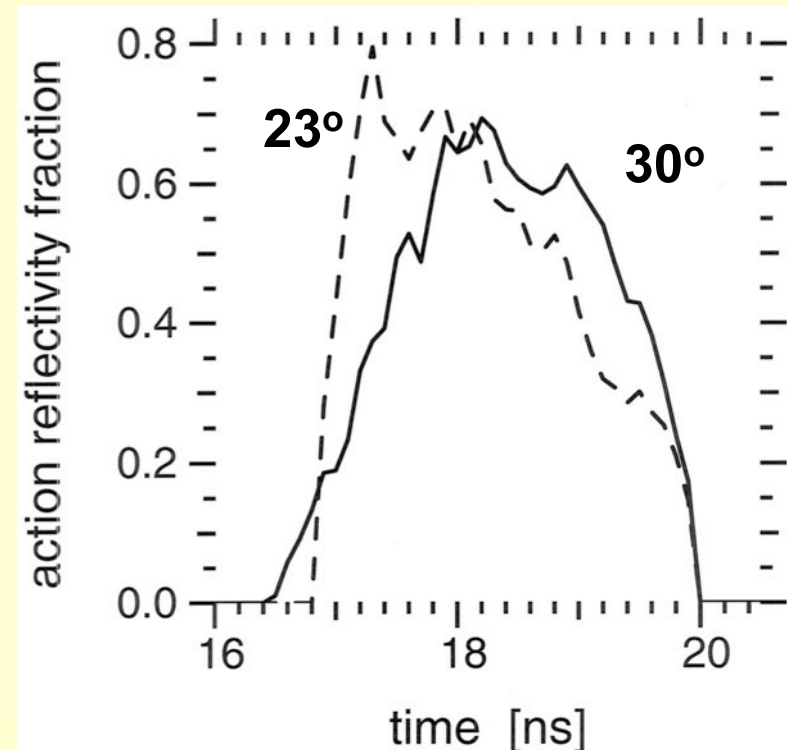
Shot N111014: substantial SRS on both inner cones; little SBS

Laser and backscatter powers



- 3 laser colors used:
 - more transfer to 23° cone to tune azimuthal symmetry

SRS w/ post-transfer power

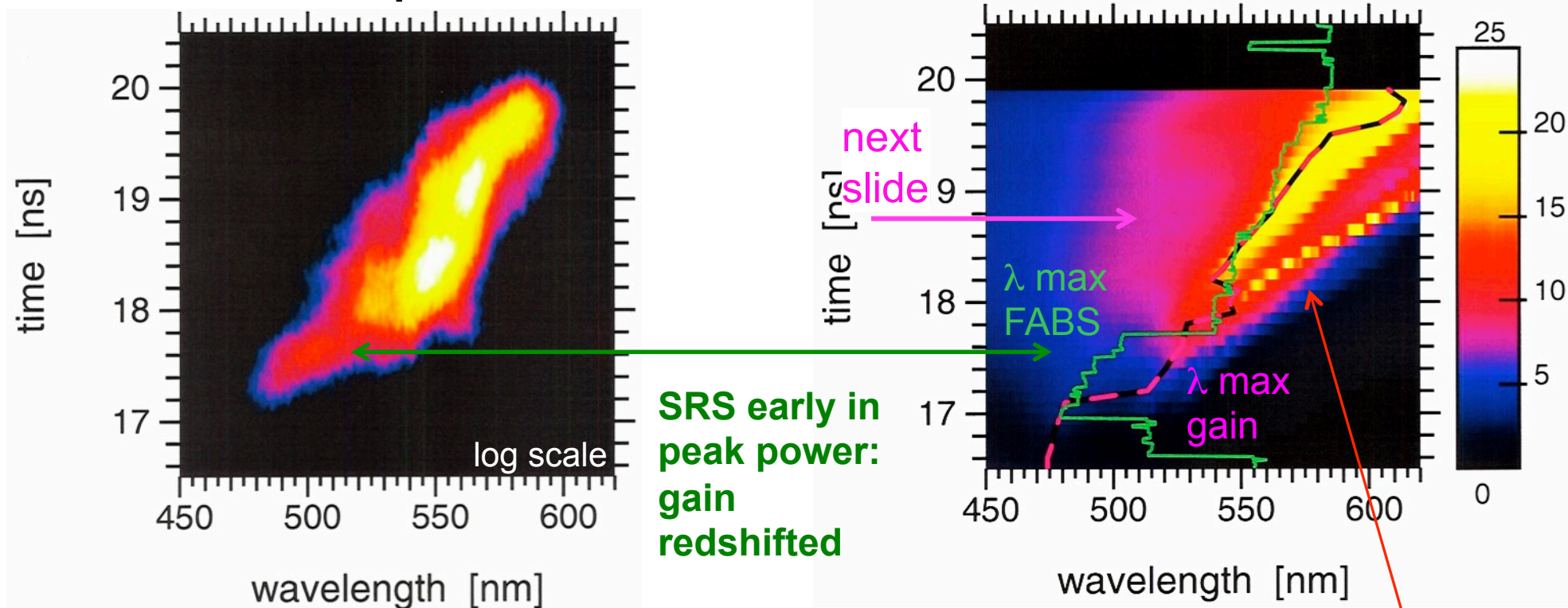


- Significant SRS early in peak power
- SRS drops before laser power late in pulse

action reflectivity: accounts for plasmon energy by Manley-Rowe, max. of unity

Shot N111014, 30° cone: SRS gain spectrum with high-flux model simulations vs. measurements

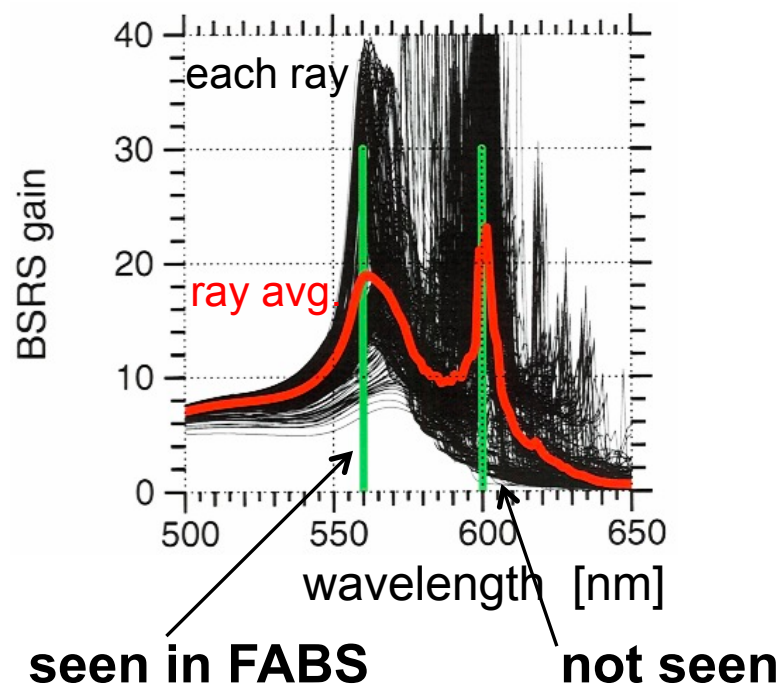
measured SRS spectrum in FABS gain spectrum from LASNEX simulation



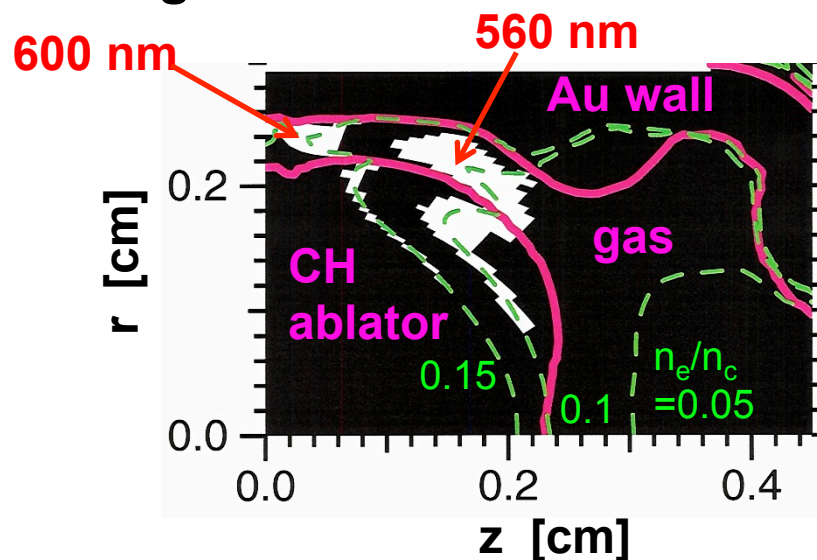
- Rise to peak power: gain redshifted vs. measurement
- mid peak power: good agreement
- late peak power: gain redshifted again

Shot N111014, 30° cone: SRS gain from two distinct regions; one from high density not observed

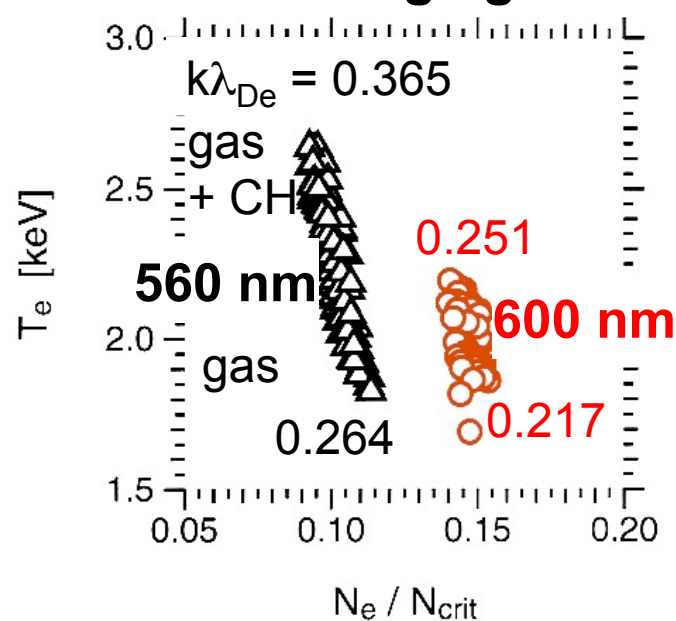
gain spectrum at 18.8 ns



Gain regions for different wavelengths



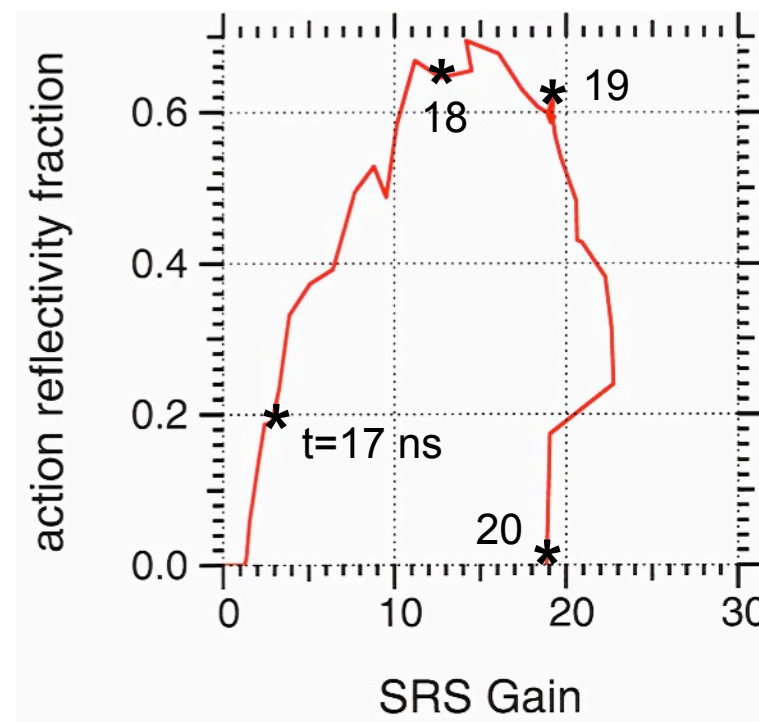
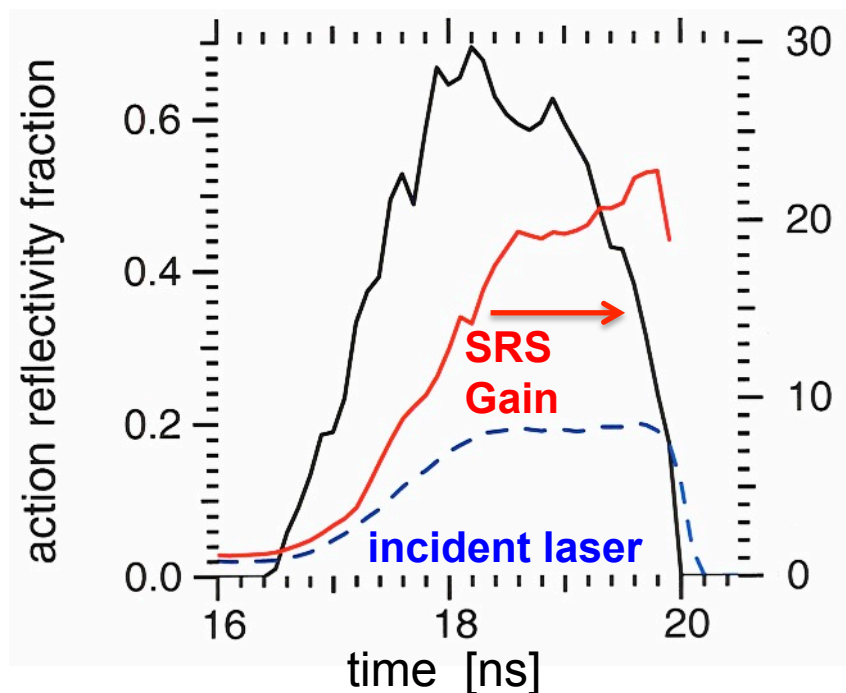
zones with high gain



Why 600 nm SRS not seen?

- scattered light refracted out of FABS
- pump depletion from 560 nm SRS
- re-absorption
- plasma conditions
- CH / gas mix
- Langmuir decay instability saturation?

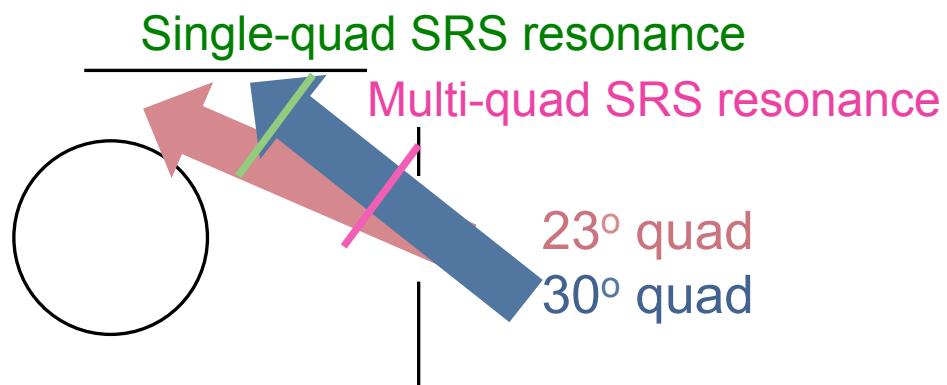
Shot N111014, 30° cone: reflectivity(t) vs. peak gain(t) from “560 nm” branch



- Early peak power: large reflectivities but small gains
- Late peak power: reflectivity drops but gains rise
- Possible reasons:
 - plasma conditions not right early in peak power
 - cross-beam transfer: saturation clamp, time history, spatial non-uniformity
 - re-amplification by crossing lasers
 - kinetic inflation early in time

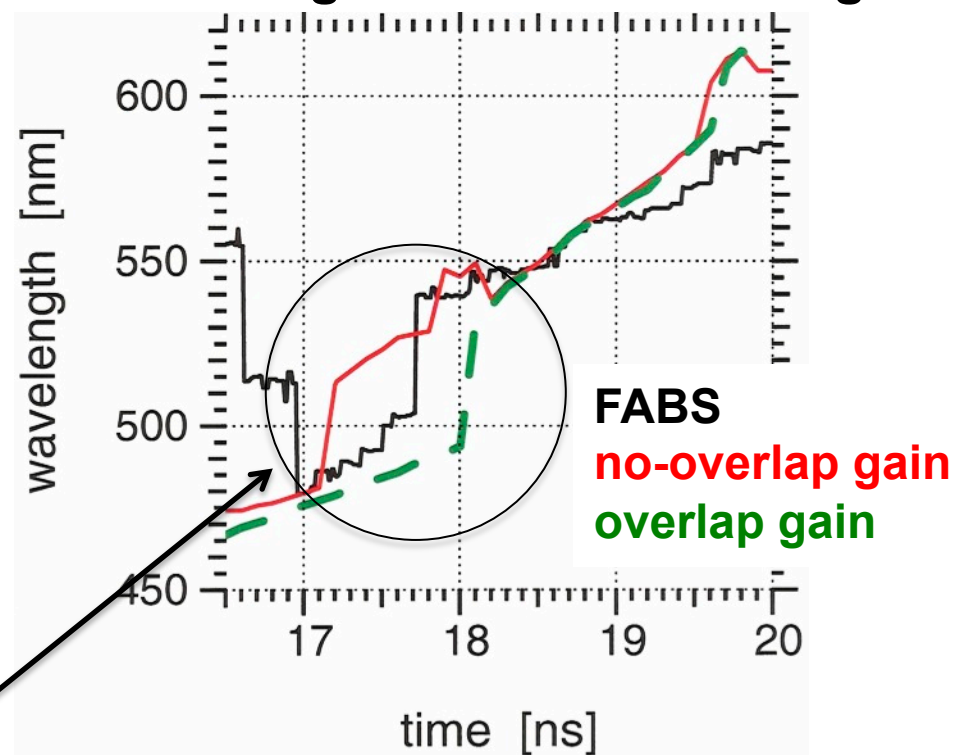
gains with overlapped laser intensity: 5 nearest neighboring quads

Shot N111014, 30° cone



- Multi-quad gains peak at shorter wavelength than single-quad gains:
 - beams overlap near LEH: lower electron density

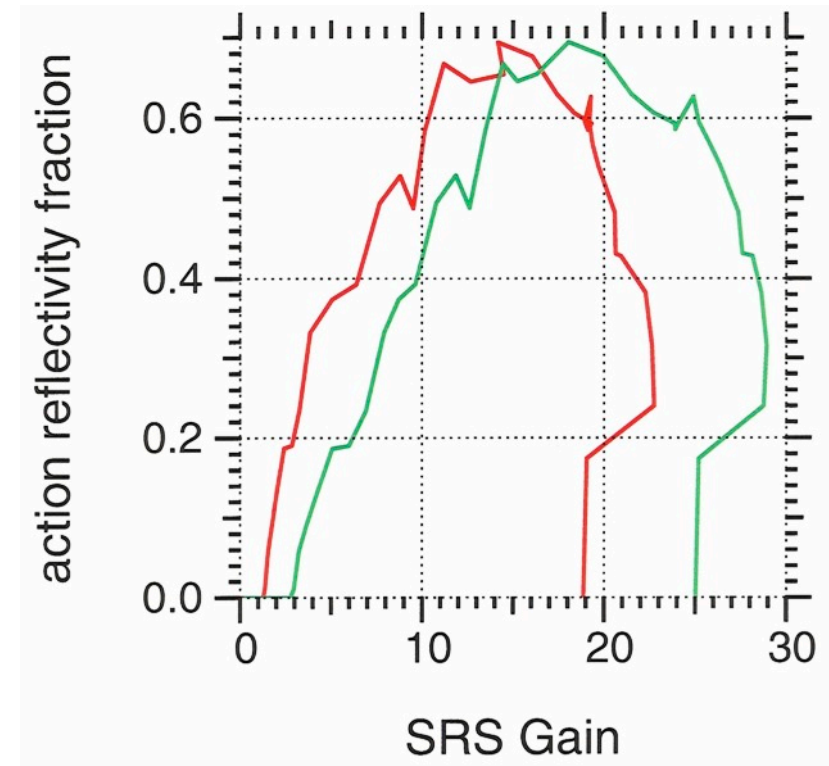
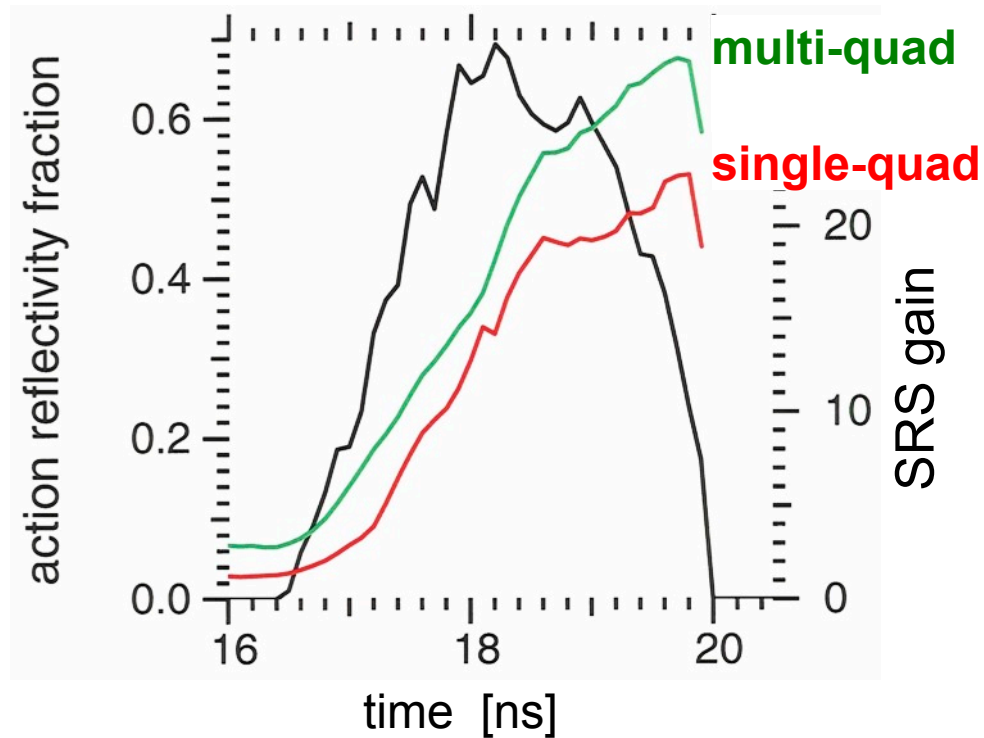
wavelength of max. FABS or gain



- Early peak power: single- and multi-quad gains bracket observed wavelength
- Late peak power: gain peaks beyond overlap region, single- and multi-quad agree

Multi-quad gains are larger than single-quad; same qualitative time history

Shot N111014, 30° cone:



SRS on NIF: better PLI (plasma, laser, and interaction) models should improve connection of gain to experiment

- **Early peak power: current understanding is incomplete**

- Single-quad gain **redshifted** vs. measurement
- Multi-quad gain **blueshifted**: brackets measurement

} plasma conditions

- Large reflectivity for small gain
- cross-beam transfer
- Re-amplification
- Kinetic inflation

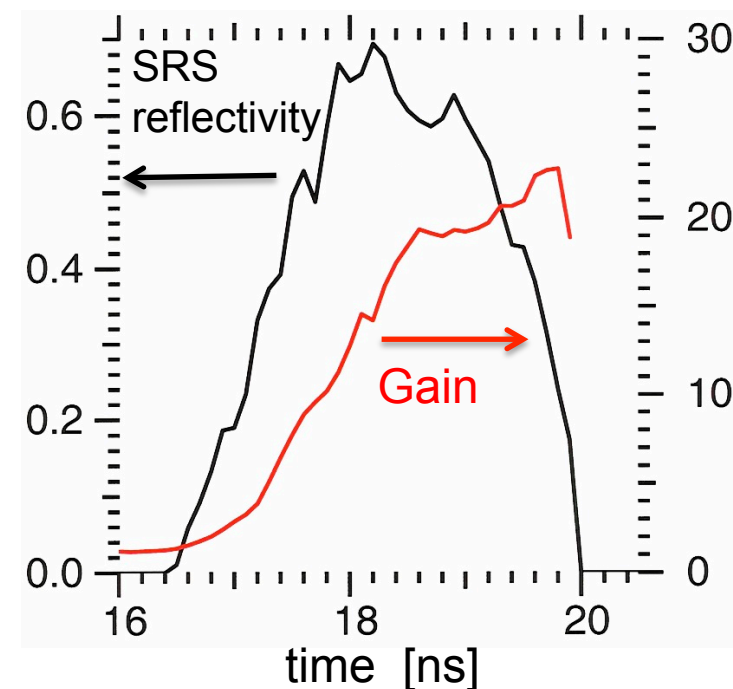
} laser model
} interaction physics

- **Mid peak power: Gain and measured spectra agree**

- Reflectivity large for gain 15-20

- **Late peak power: reflectivity drops, gain doesn't**

- Gain **redshifted** vs. measurement again
- Scattered light refracted out of detector?
- Re-absorption?
- Trapping / Langmuir decay instability saturation?

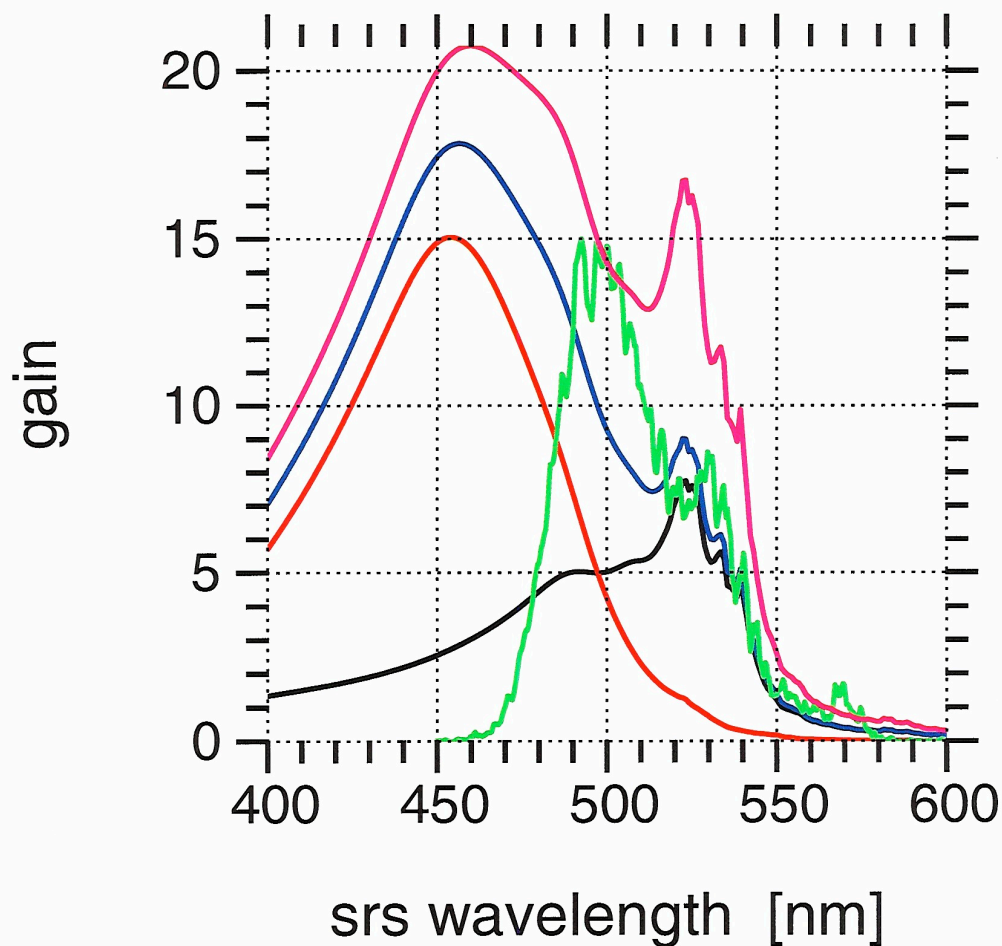


NIC



Backup slide

time = 17.5046 ns
one Q [blk], other 23 [red], sum [blue]
FABS [grn] 2*G1+others [mag]



n111014dcafbfs_dl7.5_1_sat6.0e-4